Wheelchair use in everyday life

Chris Maurer
Sharon Sonenblum
Stephen Sprigle

Why understand wheelchair use in everyday environments?

- Clinicians and users
  - Relating a clients use (or anticipated use) relative to others may better inform decisions about models and configurations.
- Manufacturers and Suppliers
  - Better information about how products are used can inform design of their products and compare products.
- Payers
  - Any data that relates mobility to health or independence or secondary complications should inform policy. We can and should learn more about use to better distinguish users, and therefore coverage.

Characterizing Manual Wheelchair Use-Study 1

- 6 manual wheelchair users
- Inpatients of rehab facility in UK
- Activity monitor mounted to wheel

Wilson SKM, Haslet PM, Granat MH. Objective assessment of mobility of the spinal cord injured in a free-living environment. Spinal Cord (2008) 46, 352-357

Daily averages

Subj #	Avg Time moving/day (hr)	Avg distance/day (km)	Day-to-day covariance (%)
2	1.89	4.98	34
3	0.64	1.2	55
4	0.88	1.78	14
5	1.34	2.43	57
6	1.43	2.23	20
7	0.58	1.06	29

Characterizing Manual Wheelchair Use-Study 2

- 52 Athletes from VA Games
- 2.457 Km (sd= 1.20 km) over 47.9 min (sd=21.4)
- Employed subjects
  - 3.4 km

Tolerico, M, et., al ; Assessing mobility characteristics and activity levels of manual wheelchair users. JRRD 2007

Characterizing Manual Wheelchair Use-Study 3

- 6 full time users living in the community
- Seat occupancy switch
- Accelerometer-based data logger on wheel

Distance, time moving & bouts of mobility

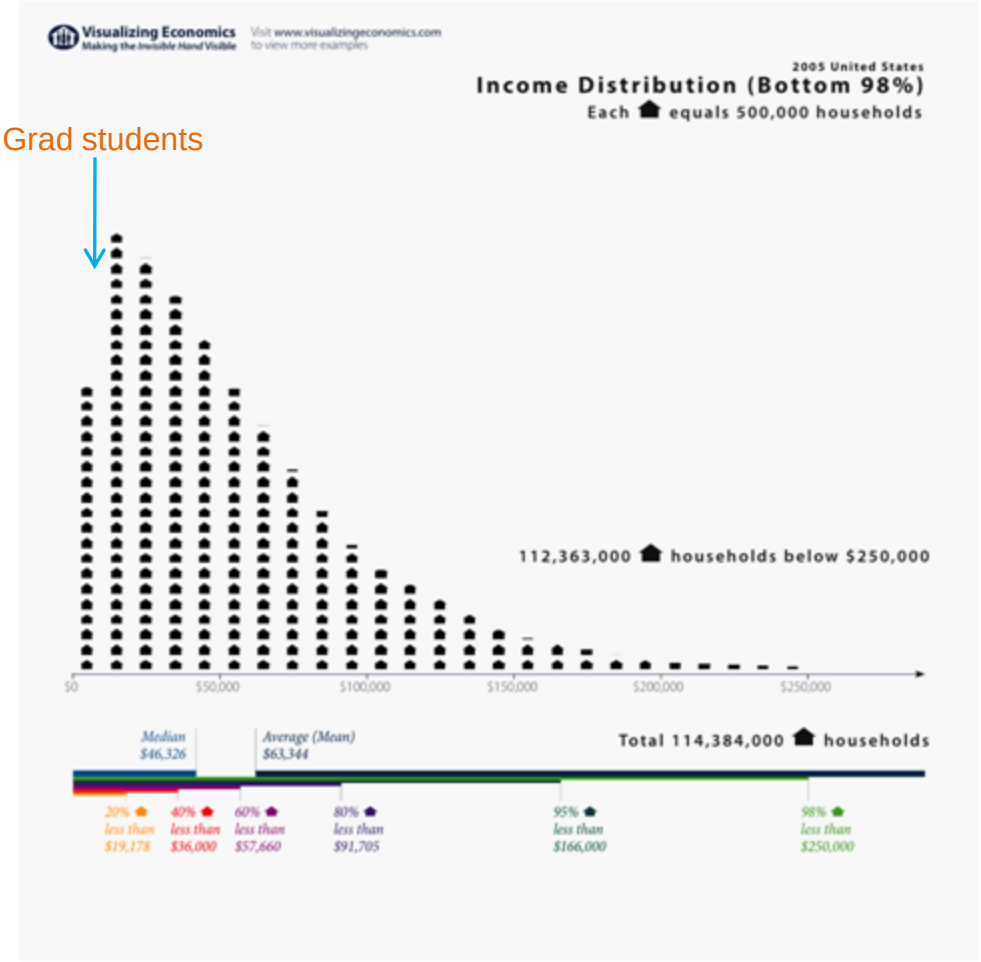
- Three constructs, 2 are commonly described
- Bouts of movement
  - Represent transitions between activities
  - Technical definition
    - Movement that is > 2 ft in ≤ 5 sec
- Distance and time are very highly correlated
- Bouts are least correlated to distance and time in MWC and PWC data
- Data varies widely within and across subjects

Mean vs median

- Why look at median versus mean?
- Example: Income in the US
  - Normal or skewed?
  - What is the mean? median?

Median= 46,300
Mean= 63,300

20% < $29,200
40% < $36,000
60% < $57,700
80% < $91,700
95% < $166,000
98% < $250,000



Median and ranges of movement

Subject	Distance (m)		Time (min)		Number Bouts	
A	2295	(1710 - 3062)	95	(80 - 133)	113	(88 - 151)
B	1153	(523 - 2605)	61	(42 - 75)	81	(63 - 93)
C	1167	(875 - 1233)	87	(84 - 88)	119	(118 - 133)
D	676	(103 - 1150)	35	(7 - 46)	46	(14 - 60)
E	1375	(700 - 1731)	71	(39 - 91)	92	(58 - 112)
F	3596	(1577 - 4694)	134	(82 - 153)	136	(114 - 178)

Subjects A, E & F are employed

Characterization of Power Wheelchair Use in the Home and Community

- 25 full-time power users
- Monitored for 2 weeks
  - Seat occupancy
  - Wheel movement
  - GPS
- Prompted recall used to add context & detail

Sonenblum SE, Sprigle S, Harris FH, Maurer CL, "Characterization of Power Wheelchair Use in the Home and Community," Archives of Physical Medicine and Rehabilitation **89(3),** 486-91, 2008.

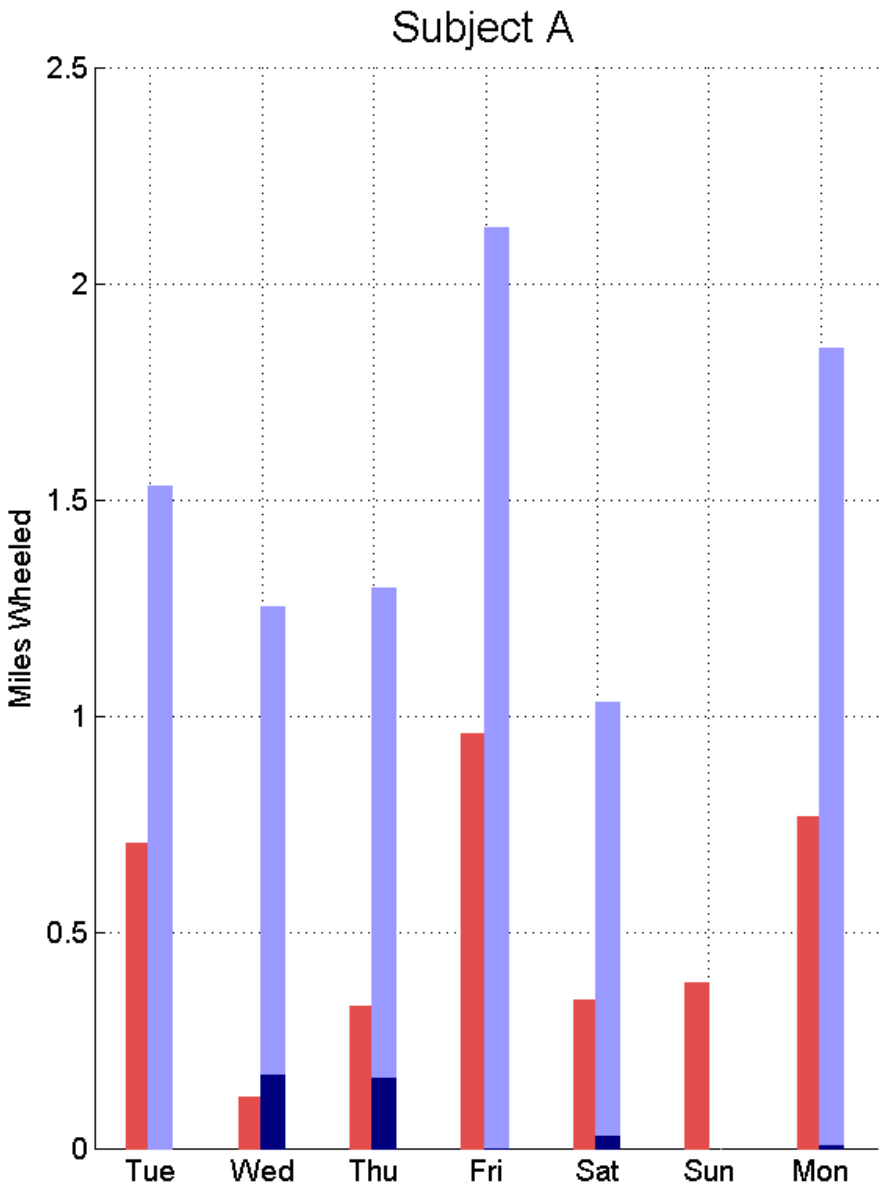
Wheelchair Use By Environment

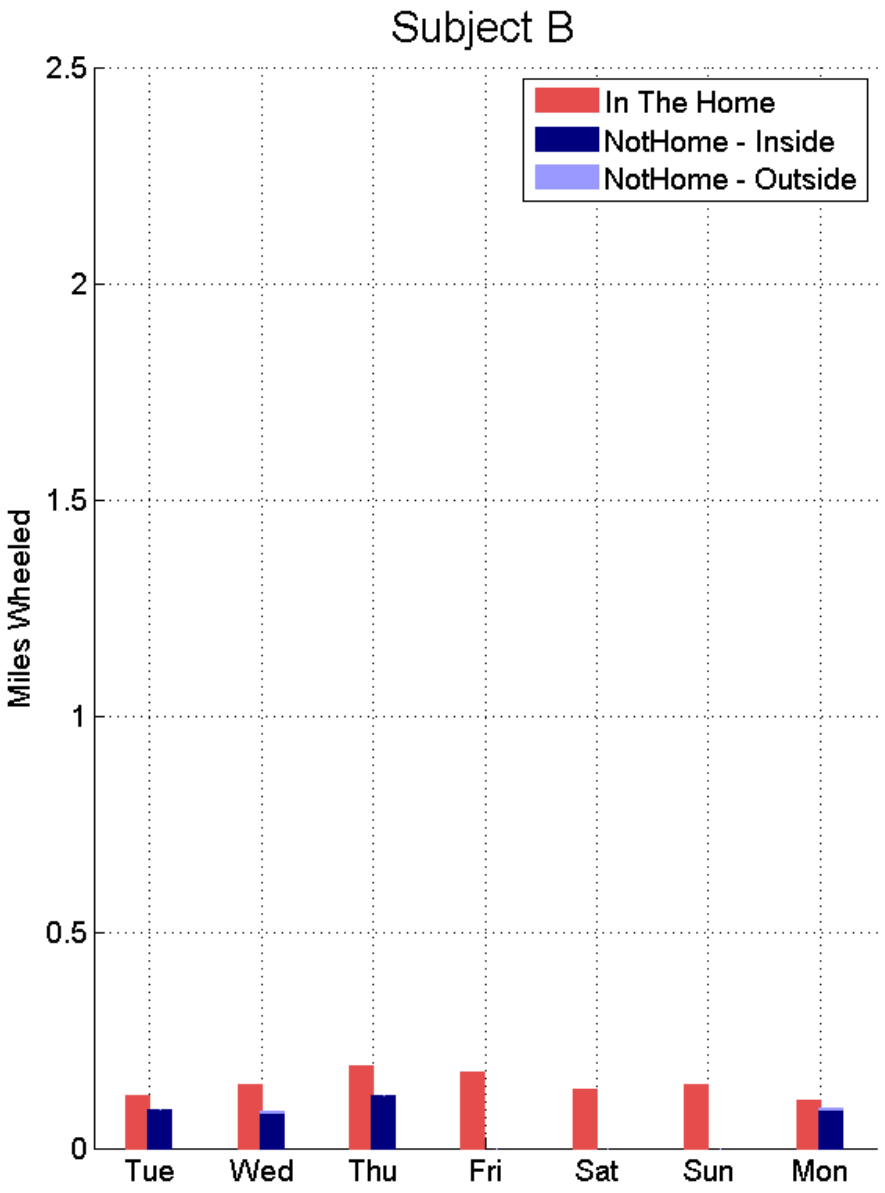
Environment	Variable	Median	Mean	SD
Home	% Distance	59	57	30
	% # Bouts	75	71	23
	% Time	64	63	27
Not Home Indoors	% Distance	13	22	18
	% # Bouts	13	19	17
	% Time	11	20	17
Not Home Outdoors	% Distance	2	19	29
	% # Bouts	2	8	12
	% Time	2	15	22

Median bout characteristics differ based on environment.

	Distance (m)	Duration (sec)	Speed (km/hr)
Home	3.7	18	0.8
Not Home Indoors	4.2	18	1.0
Not Home Outdoors	11.3	34	1.6

Comparing two users





10 vs 14” wheels

Comparing usage

- PWC study- the median user
  - spent 10.6 hours in his/her wheelchair daily
  - wheeled 1.085 km over 58 minutes
  - 110 bouts
- MWC study- the *median* inpatient
  - Wheeled 2.0 km over 67 minutes
- MWC study- *mean* of Veterans Games participants
  - 2.457 Km over 47.9 min
- MWC study- the *median* community user
  - 1.33 km over 77 min
  - 101 bouts

How do people walk?

- How humans walk: Bout duration, steps per bout, and rest duration; Orendurff MS, Schoen, JA, et. al; 2008
  - 10 subjects measured over 14 days
  - **90% of walking bouts <100 steps**
  - **40% of bouts <= 12 steps**
  - **<1% of walking bouts lasted 2 minutes**
- The role of free-living daily walking in human weight-gain and obesity. Levine, JA, et. al; Diabetes. 2008
  - **"walking comprises many short-duration, low-velocity walking bouts"**
  - **On average, a participant took 47 (range 46-62) walks per day: 85% were <15 min in duration, and 88% occurred at <2 mph;**
  - **On average, people walked about 11.25 km/day (7 miles)**
- Measurement of daily walking distance-questionnaire versus pedometer , Bassett D, Cureton A, Ainsworth B; Med & Sci in Sports & Exercise, 2000.
  - **Average: 4.17 ± 1.61 km**
- How Many Steps/Day Are Enough?: Preliminary Pedometer Indices for Public Health. Tudor-Locke C, Bassett Jr D - Sports Medicine, 2004
  - **<5000 steps: sedentary (2.25 to 3 km)**
  - **5000-7500: typical (3.4-4.5 km)**

Why we should care

- Daily use varies widely within a person
- Use varies widely across people
- Movement is characterized by short bouts of movement
  - For PWC, this indicates need for maneuverability more than top speed
  - For MWC, this indicates that starts, stops and turns dominate propulsion
- Even if one considers only ITH, disparity of use can inform prescription (10” wheel vs 14”)
- Repair and replacement frequency is impacted by wheelchair usage

Why we should care- MWCs

- Research has not defined a dose-response relationship between time of MWC use and UE overuse injury
  - The disparity in propulsion might have masked this relationship
  - Documenting bouts of mobility and time moving might be a better measure

Why we should care- MWCs

- Can comparing average speed data to our clients' speeds inform prescription?
  - A client unable to reach the average speed necessary for 'everyday mobility' may form basis for different MWC or need for PWC
- Should research into propulsion reflect speeds used in everyday mobility?
- Endurance – total time propelling leads to 2 considerations
  - Enough 'umph' at end of the day
  - Able to get to point B from Point A (longest trek)

Comparing wheelchair use to walking

- Studies of both produce disparate results
- However, wheelchair movement is quite low, comparatively
- Can we infer walking data reflects typical ADL needs?
- Can we use this comparison to
  - judge ‘mobility limitation’?
  - make an argument that mobility devices should facilitate equal movement ?

Use of tilt-in-space

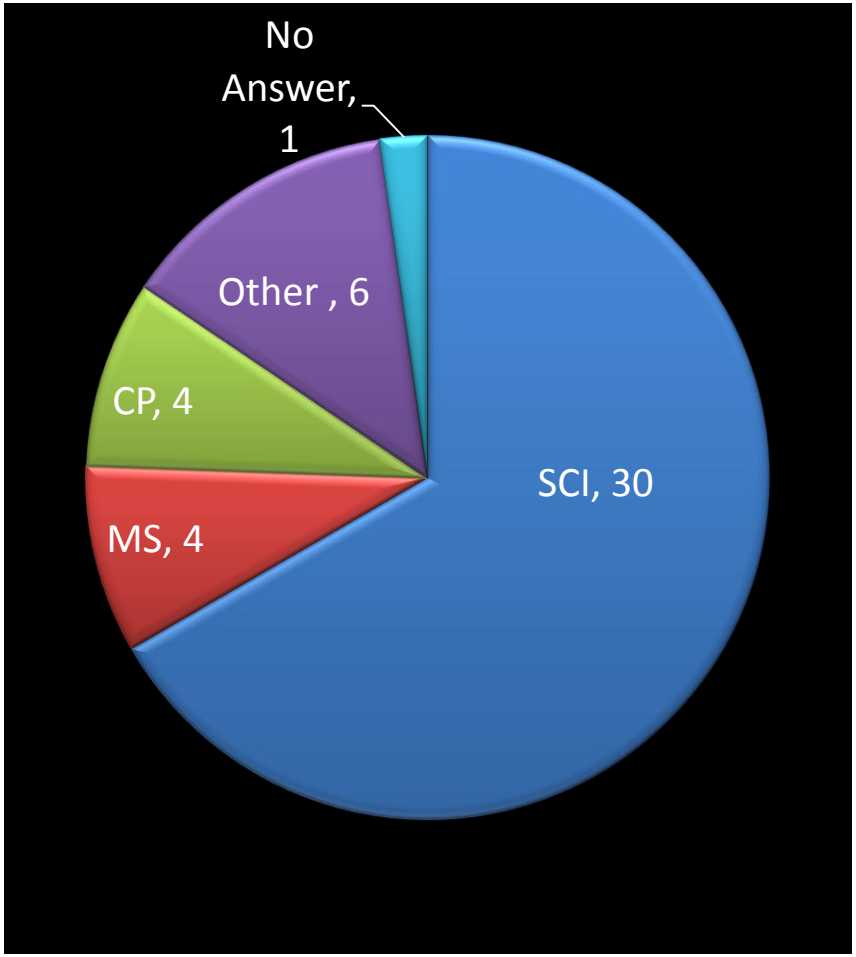
- Obtaining of specialized wheelchair features can be problematic
- Understanding use of TIS
  - Better document indications
  - Inform ways to optimize usage
  - Better match devices to users
- Recent publications: very consistent results
  - Ding, D., E. Leister, et al. (2008). "Usage of tilt-in-space, recline, and elevation seating functions in natural environment of wheelchair users." Journal of Rehabilitation Research & Development **45(7): 973-984.**
  - Sonenblum, S. E., S. Sprigle, et al. (2009). "Use of Powered Tilt Systems in Everyday Life." Disability and Rehabilitation: Assistive Technology **4(1): 24-30.**
- Small n (11 and 16)

Participant Characteristics

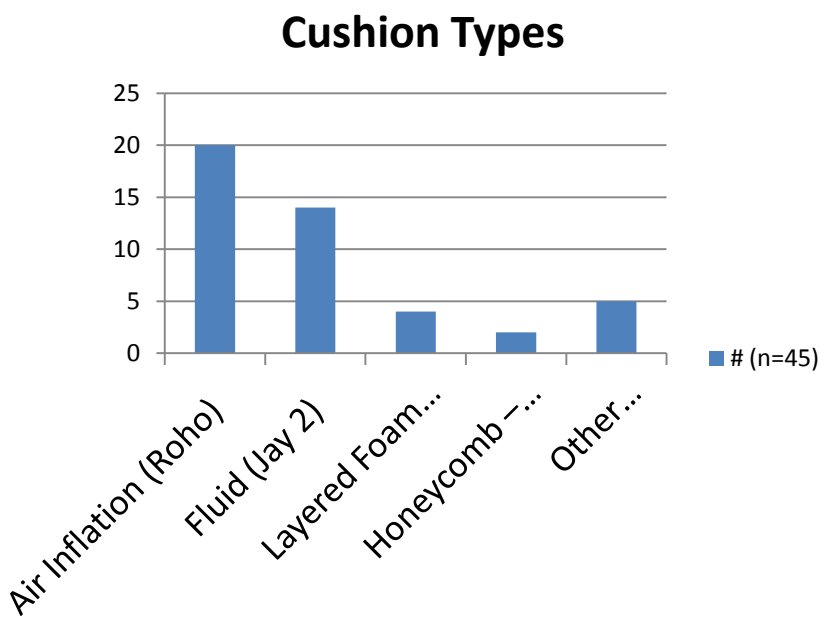
- n = 45 Participants!
- Age: 45 ± 14 years (range: 22-69)
- Height: 1.74 ± 0.11 m
- Weight: 75 ± 19 kg
- 33 Men, 12 Women
- 25 white, 18 black / African-American, 1 biracial

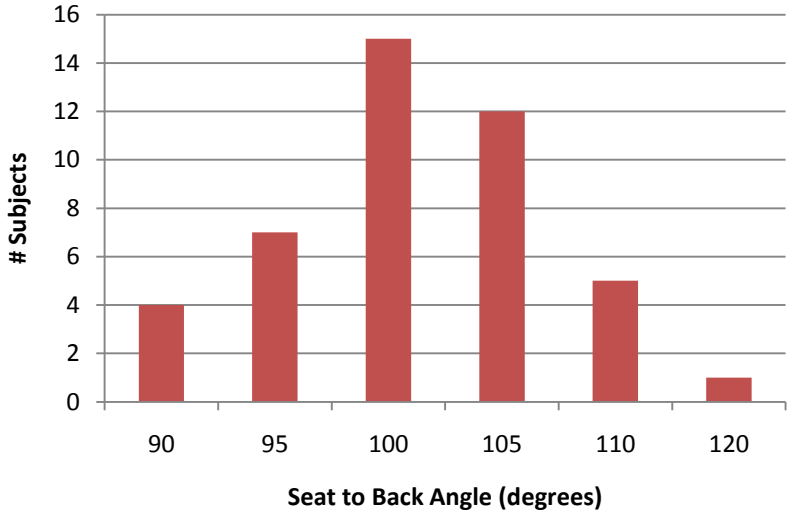
Participant Characteristics

- Years Using a WC
  - Median (range): 10 (0.5 – 50)
  - Mean ± SD: 14.4 ± 13.5
- Years Using a TIS WC
  - 3 (0.25 – 20)
  - 6.1 ± 6.1
- Years Using Current TIS WC
  - 1.5 (0.1 – 10)
  - 2.2 ± 2.3

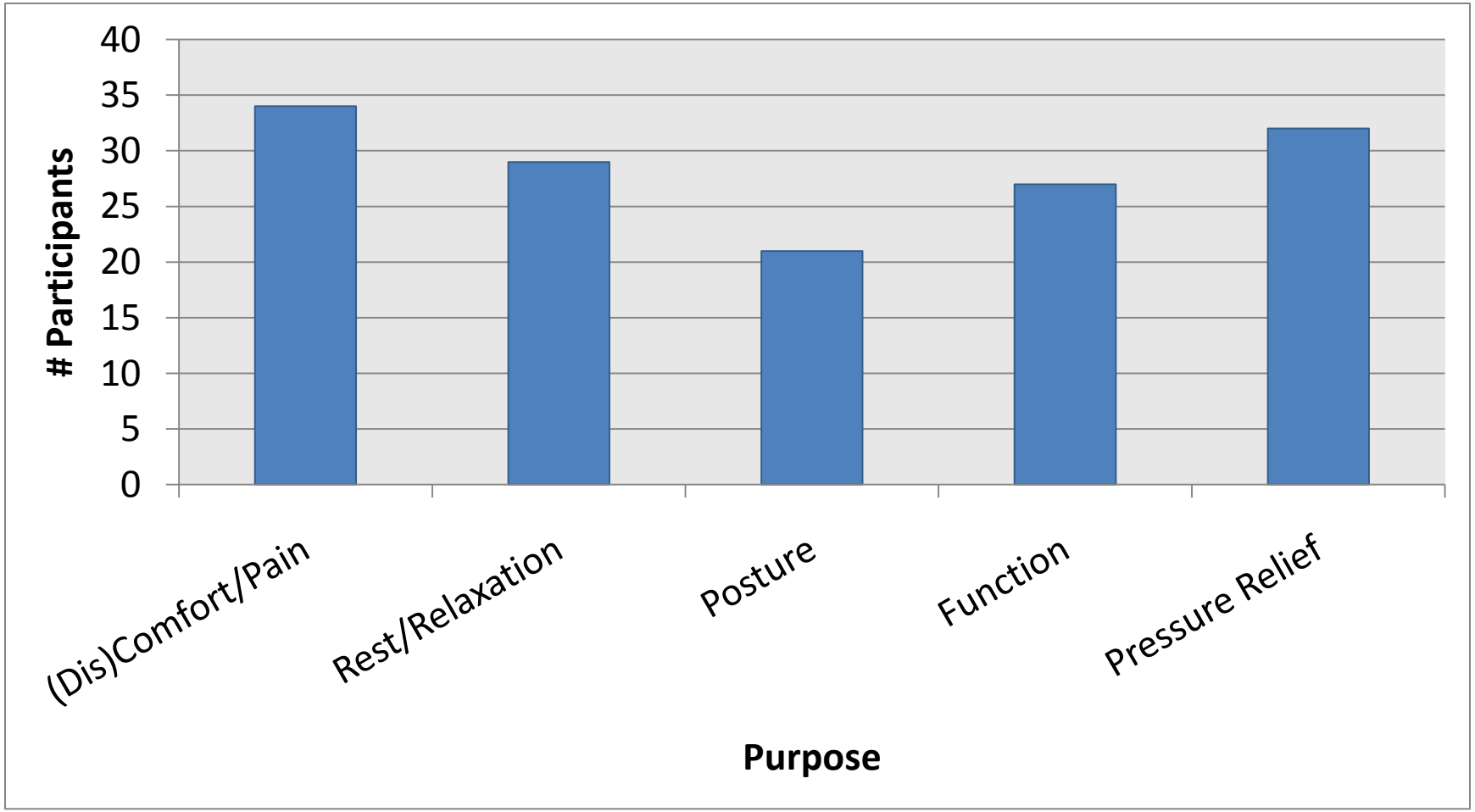


Wheelchair Configurations



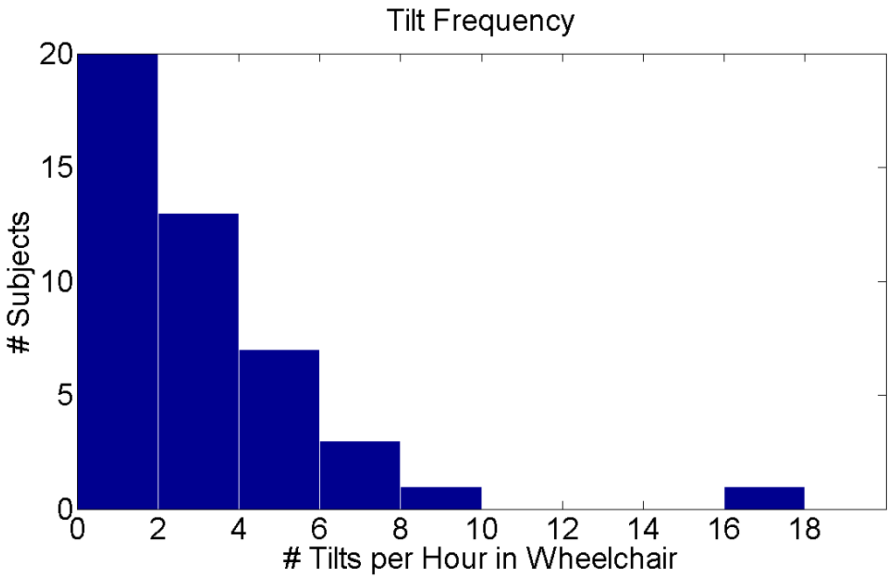


Self Reported Purposes for Tilt Use

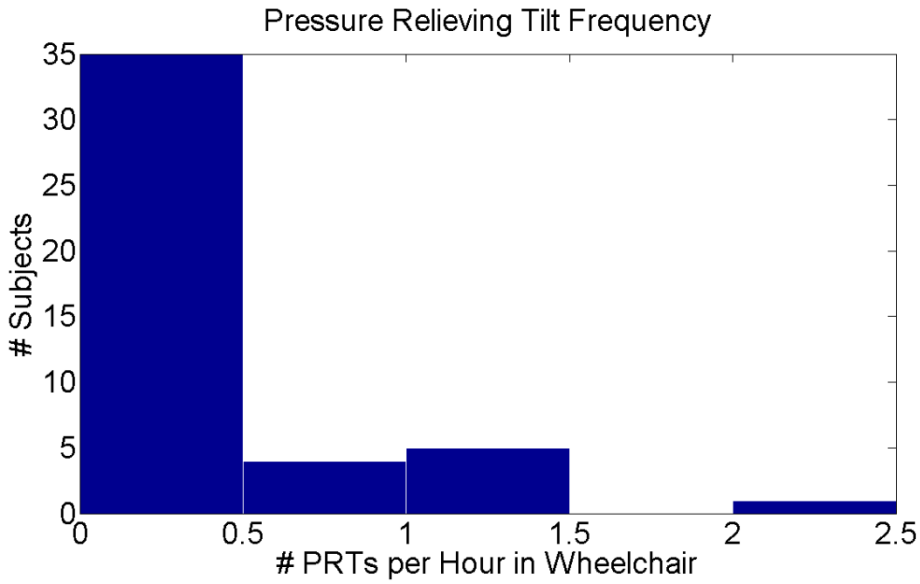


Hourly Use of Tilt

All use of tilt feature
(Angle change of 5^{o} lasting > 20 seconds)



“Pressure Relieving Tilts”
(Tilts > 30^{o} lasting > 1 minute)



Use of Tilt-in-Space Wheelchairs

Variable	Median (Min – Max)	Mean ± SD
Occupancy Time (hours)	12.1 (4.1 – 24)	11.7 ± 3.7
Typical Position (º)	8 (0 – 47)	11 ± 9
Tilt Frequency (tilts/hour)	2.2 (0.1 – 16.6)	3.0 ± 2.9
PRT Frequency (tilts/hour)	0.1 (0.0 – 2.2)	0.3 ± 0.5

Sensation and Ability to Reposition

- Hypothesized to affect tilt behavior
- Sensation based on self reported ability to feel any:
  - Light touch
  - Deep pressure
  - pain
- Ability to reposition is NOT the same as ability to do a weight shift.
  - Ability to unload trochanter by 75% or more (can they squirm?)

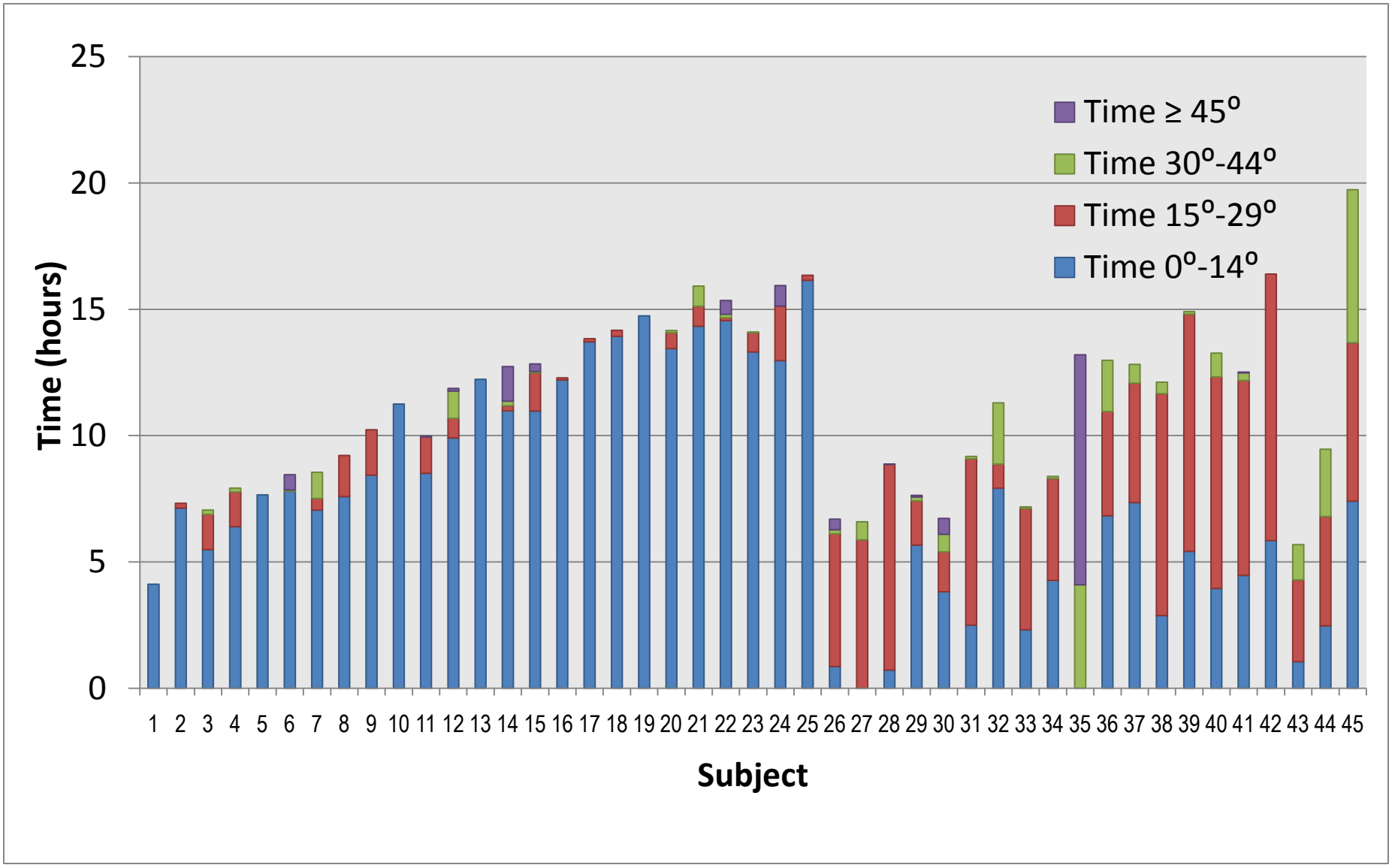
Use of Tilt-in-Space Wheelchairs

Variable	Median (Min – Max)	Mean ± SD
% Time 0º - 14º	81 (0 – 100)	65 ± 33
% Time 15º - 29º	15 (0 – 92)	26 ± 28
% Time 30º - 44º	1 (0 – 29)	5 ± 8
% Time ≥ 45º	0 (0 – 71)	3 ± 11

- Ability to reposition → more time at a small tilt
  - With ability to reposition: 85% time at small tilt
  - Without ability to reposition: 50% time at small tilt

What about Pressure Reliefs?

- 7/9 of the participants with *current pressure ulcers* performed PRTs more frequently than median subject overall (> 0.1 / hour)
- 15/45 participants (1/3) did not do a single pressure relieving tilt on their median days
- People who said they were using their tilt for pressure reliefs performed
  - more tilts (2.4 versus 1.0 per hour)
  - more pressure relieving tilts (0.18 versus 0.0 per hour)
- BUT… 22 / 42 said they performed pressure reliefs in some way besides tilting (often leaning to the side or forwards)
- People who did other pressure reliefs in addition to tilts did significantly MORE pressure relieving tilts
  - Other pressure reliefs – median PRT Freq = 0.2 / hour (1 every 5 hours)
  - No other pressure reliefs – median PRT Freq = 0.0 / hour


Time ≥ 45°
Time 30°-44°
Time 15°-29°
Time 0°-14°
Time (hours)
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5
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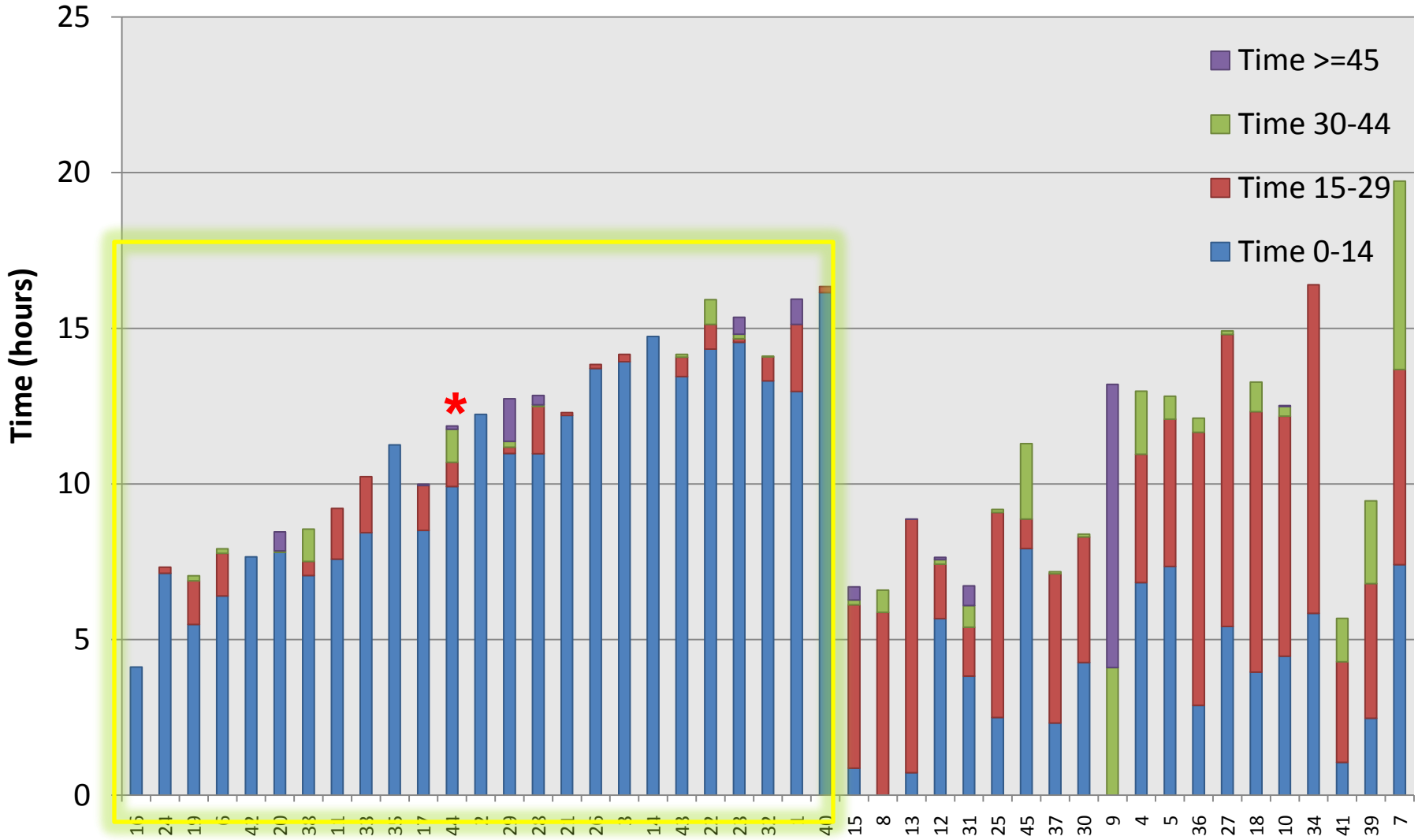
25
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
Subject


Time (hours)
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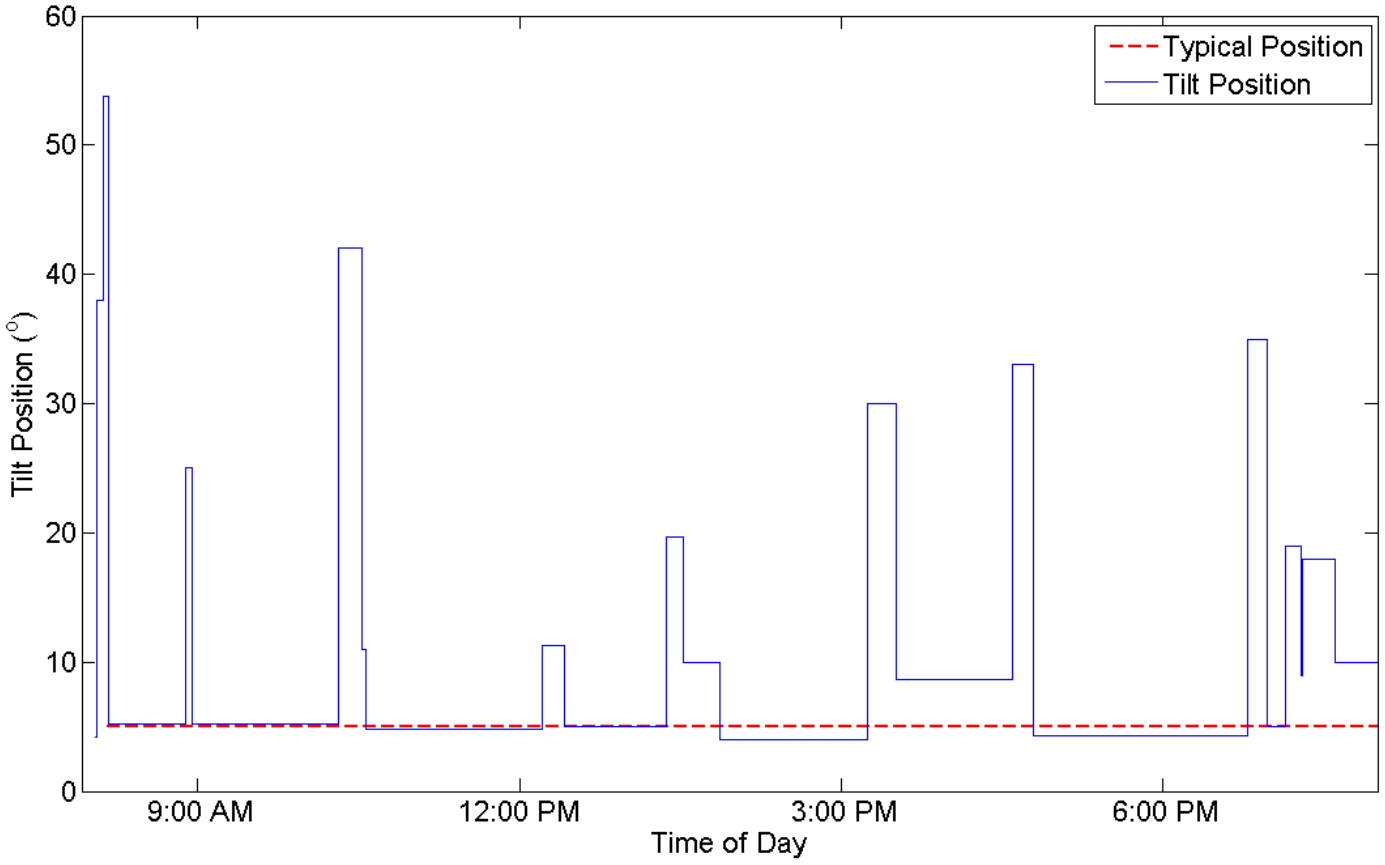
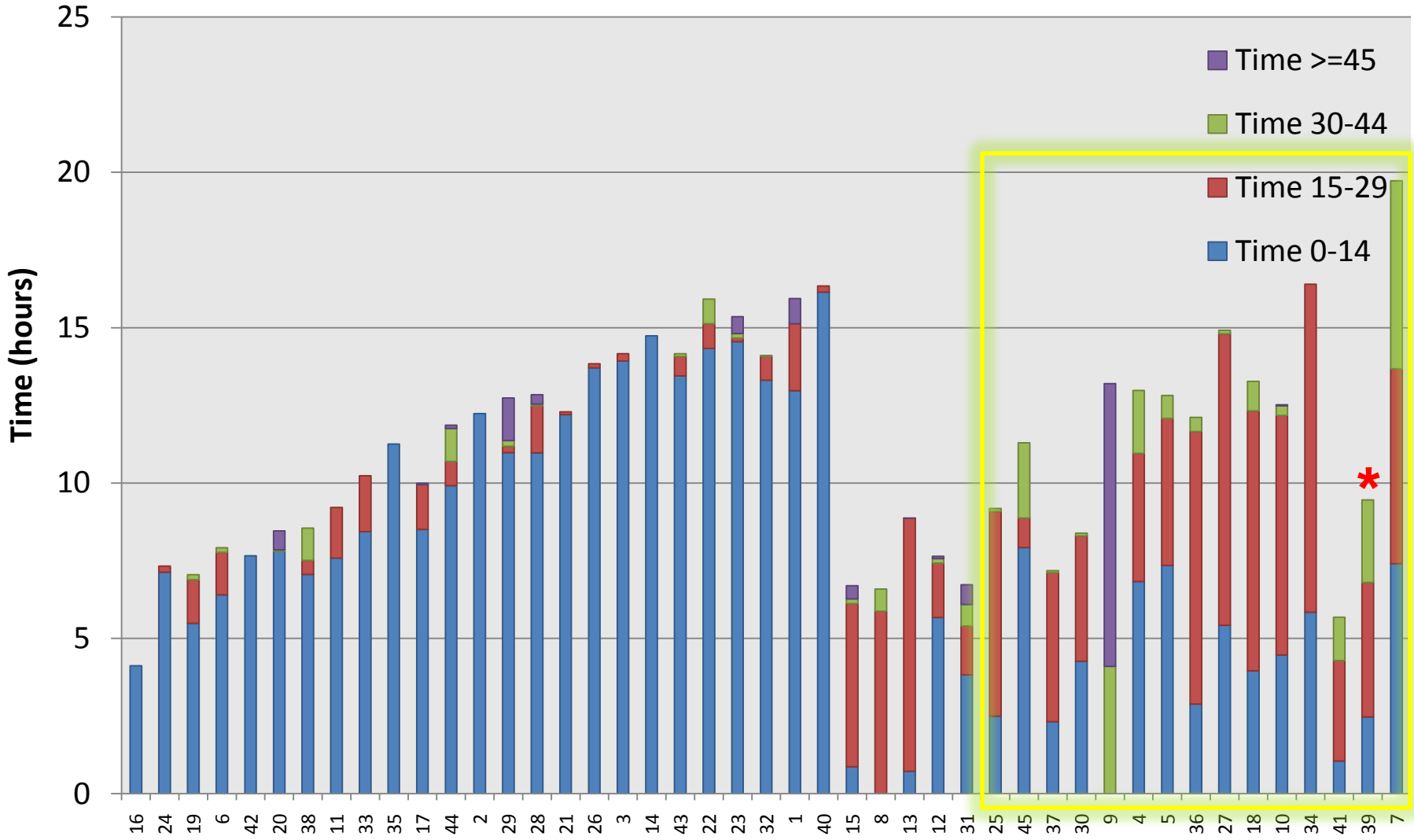
Example Participant with "Single Typical Position"




Time (hours)
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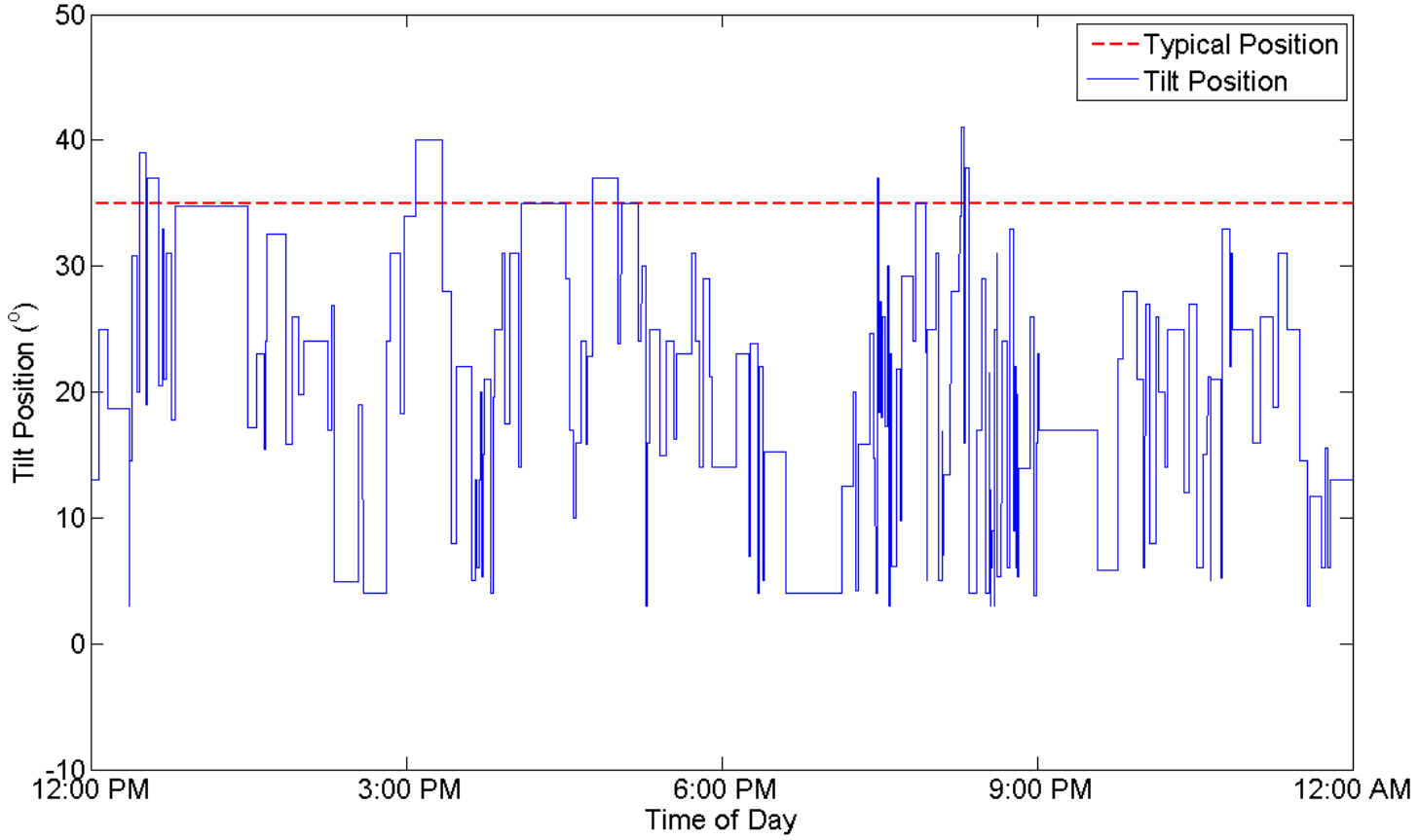
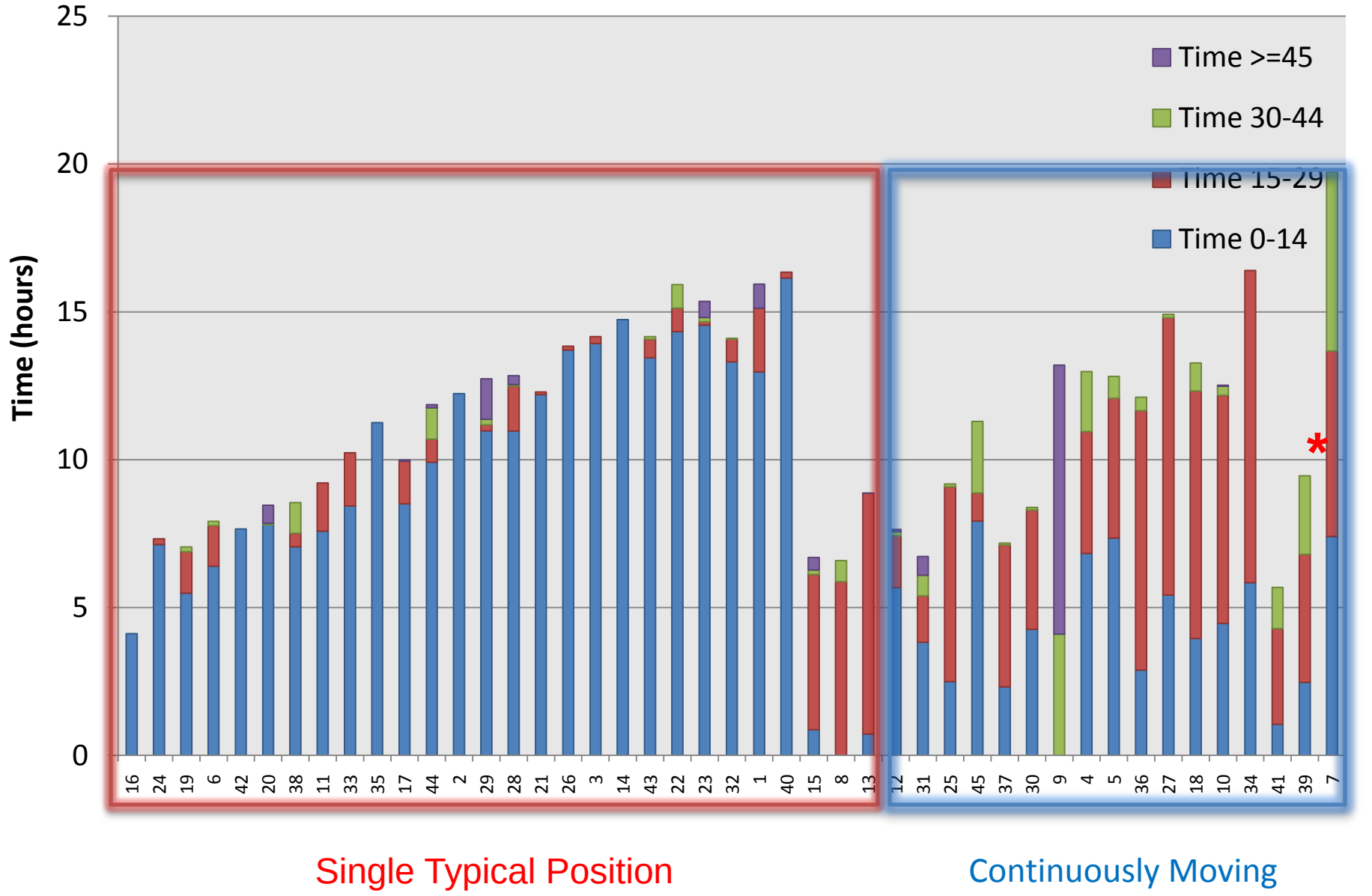
*
16 24 19 6 42 20 38 11 33 35 17 44 2 29 28 21 26 3 14 43 22 23 32 1 40 15 8 13 12 31 25 45 37 30 9 4 5 36 27 18 10 34 41 39 7

Example Participant who Moves Continuously (No “Single Typical Position”)




Time (hours)
25
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Time >=45
Time 30-44
Time 15-29
Time 0-14
16 24 19 6 42 20 38 11 33 35 17 44 2 29 28 21 26 3 14 43 22 23 32 1 40 15 8 13
12 31 25 45 37 30 9 4 5 36 27 18 10 34 41 39 7
*
Single Typical Position
Continuously Moving

Tilt Behavior: Continuously Moving (n=17)

- Defined at > 20% of time in more than one tilt size
- 4 participants from continuously moving group did hourly pressure relieving tilts
- More frequent tilts (p = 0.001)
  - Continuously Moving: 4.0 tilts / hour
  - Single Typical Position: 1.3 tilts / hour
- More frequent pressure relieving tilts (p = 0.035)
  - Continuously Moving: 0.24 tilts / hour (≈ every 4 hours)
  - Single Typical Position: 0.07 tilts / hour (≈ every 14 hours)
- More common among persons with sensation
  - Continuously Moving: 12/15 (80%) have sensation
  - Single Typical Position: 14/27 (52%) have sensation
- Not related to ability to reposition

Questions Raised

- What does the “continuous movement” type of tilt behavior teach us about the benefits of tilt outside of pressure relief?
  - Can it help with justification?
- Why aren’t people doing more large tilts?
- How can we get people to do more pressure reliefs?
- Are we giving tilts to the right people? Or not giving tilts to people who would benefit from them?
- Do small tilts provide any benefit in terms of pressure relief? (maybe!)
- Should people perform small tilts between large tilts?

Why should we care?

- People use their TIS feature frequently
  - May indicate that small changes in position increase comfort , stability and/or function
  - Regardless of the reason, use of feature should be encouraged during set-up and training
- Many people sit in some tilt for extended periods
  - May indicate gravity-assisted positioning is sought
  - Perhaps we can investigate this during evaluation for and training of TIS systems

Can we increase tilt magnitudes?

- Few people use full ranges of TIS feature
  - We have no reason to obsess over small differences in maximum tilt magnitudes
  - Our obsession should be in increasing utilization
- Better training and education may be indicated
  - During delivery, all users should be brought through full tilt range
    - Reports of confidence issues
    - Lack or awareness of reason TIS was prescribed
  - Perhaps IPM can be used as a training tool

Done

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